

Vegetation Mapping at Bryce Canyon

By Dan A. Foster, Resource Management Specialist, Bryce Canyon National Park

In the early 1950's a map of the vegetation of Bryce Canyon National Park was completed. It is uncertain who or when this was completed, as there is no supporting documentation to the map. This remained the only vegetation map for the park until 1990 when a parkwide effort was completed in 1992 by staff of Utah State University. The latter effort was a GIS model of potential vegetation, provided there was no human or natural intervention.

Park staff, in desperate need of a current map delineating existing vegetation and land cover for accurate assessment of park management practices, initiated a program in 1993 to map vegetation in and around the park.

In an effort to gain a more detailed knowledge of existing vegetative resources, park personnel implemented a four part program to obtain greater in-depth information. Previous studies of plant life in the park were conducted on a generalized basis for years. These, however, appear to have been void of plant community analysis and the role played by dominant, co-dominant, and important associated subspecies. Beginning in the summer of 1993, field work was established to (1) identify plant communities and develop a park vegetative map using air photos and by on-site quantitative studies; (2) gather information on fire fuel loading for each vegetative community; (3) collect plant specimens to update park flora; and (4) locate rare plant species and their habitats.

The mapping of plant communities was begun in the summer of 1994 and completed in the fall of 1995. A community is defined as an area which contains one to several species which provide the majority of plants for that area. Using recent air photographs (1:12,000 scale color) in conjunction with topographic maps, orthophoto quadrangles, and site visits, outlines of plant communities were made. On-site visits to community types were made and transects established to measure the vegetative canopy, shrub cover, forbs and grasses, down material, bare ground, and other pertinent information.

A minimum mapping unit of 100 square meters was established and information was mapped on 46 species prominent enough to be dominant, co-dominant, or an important subspecies in a given community. As community content varied in areas of the park, information was mapped on a total of 109 species as they related to communities. All mapped information was compiled and automated into the park Geographic Information System (GIS) at a scale of 1:24,000.

In June of 1993 collection of plant specimens was begun to update knowledge on park flora. Over a two summer period more than 300 voucher specimens were collected, prepared and submitted to the Brigham Young University Herbarium in Provo, Utah for final identification and mounting. These collected specimens provide a variety of information, including (1) complexity of park flora; (2) where a given species may found; (3) representative rare species; and (4) new or unusual plant changes in park flora. This effort was invaluable in the location and mapping of rare plant species found in the park. Rare animal species were also mapped and entered into the park GIS during this period.

The completion of this effort provides park managers another data layer to aid in making more informed decisions on the management of park resources, now and in the future.

GIS VEGETATION MAPPING AND STRUCTURE INVENTORY BRYCE CANYON NATIONAL PARK

Existing Conditions

In the early 1950's a map of the vegetation of Bryce Canyon National Park was completed. It is uncertain who or when this was completed, as there is no supporting documentation to the map. This remained the only vegetation map for the park until 1990 when a parkwide effort was completed by Dave Roberts of Utah State University. The latter effort was a GIS model of potential vegetation provided there was no human or natural intervention.

The park is in desperate need of a current map delineating existing vegetation and land cover for accurate assessment of park management practices. Using GIS technology models of park management practices can be depicted. A critical component to accurate models is vegetation and land cover for wildlife habitat, wildfire and other scenarios.

Mapping Objectives

1. Develop an accurate vegetation map and enter into the park GIS.
2. Obtain information on vegetation structure and tree stand density.
3. To delineate and determine the extent of wetland areas.

Methods

1. Using aerial photographs, land cover types will be delineated. When there is evidence of a type change the area will be sampled to determine vegetative structure.
2. After aerial photo delineation, the information will be transcribed to quad sheets and entered into the GIS.
3. By using aerial photos, areas of differing cover can be delineated and serve as a driver for field sampling.
4. Random field sample points will be established in similar cover types to determine vegetative structure. This information can then be interpolated across similar types. Sample points will be located via GPS.
5. At each sample point a 100 meter transect will be established. Along the transect a nested quadrat (Daubenmier) will be used on ten meter increments to determine vegetative understory/ground cover. Walking the same transect with an eight foot pole held horizontally at breast height a measure of tree bole/limb structures that intersect the transect will be made for vegetative overstory.
6. All sampling will be recorded on field forms by site number. The information will be entered into the GIS cover for use as relational data for the vegetative cover.
7. Anomalies in cover will be noted. These include disease, lightning strikes, mistletoe, etc.

VEG95 GIS COVER LANDCOVER KEY

CODE	SCIENTIFIC NAME	COMMON NAME
abco	<i>Abies concolor</i>	White fir
acgl	<i>Acer glabrum</i>	Rocky Mountain maple
acla	<i>Achillea lanulosa</i>	Yarrow
agcr	<i>Agropyron cristatum</i>	Crested wheatgrass
amut	<i>Amelanchier utahensis</i>	Utah serviceberry
anpa	<i>Antennaria parvifolia</i>	Common pussytoes
anro	<i>Antennaria rosulata</i>	Breaks pussytoes
arfr	<i>Artemisia frigida</i>	Fringed sagebrush
arno	<i>Artemisia nova</i>	Black sagebrush
arpa	<i>Arctostaphylos patula</i>	Greenleaf manzanita
artr	<i>Artemisia tridentata</i>	Big sagebrush
asco	<i>Astragalus convallarius</i>	Lesser rushy milkvetch
aske	<i>Astragalus kentrophyta</i>	Kentrophyta
assp	<i>Astragalus species</i>	Unknown astragalus
atca	<i>Atriplex canescens</i>	Four-wing saltbush
atco	<i>Atriplex confertifolia</i>	Shadscale
bare	<i>Bare ground</i>	
basa	<i>Balsamorhiza sagittata</i>	Arrowleaf balsamroot
beoc	<i>Betula occidentalis</i>	Water birch
brin	<i>Bromus inermis</i>	Smooth or Hungarian brome
caat	<i>Carex athrostachrya</i>	Slender-beaked sedge
caca	<i>Carex canescens</i>	Pale sedge
cach	<i>Castilleja chromosa</i>	Common paintbrush
cali	<i>Castilleja linariifolia</i>	Narrowleaf paintbrush
cele	<i>Cercocarpus ledifolius</i>	Curl-leaf mountain mahogany
cema	<i>Ceanothus martinii</i>	Martin's ceanothus
cemo	<i>Cercocarpus montanus</i>	Alder-leaf mountain mahogany
chna	<i>Chrysothamnus nauseosus</i>	Rubber rabbitbrush
chvi	<i>Chrysothamnus viscidiflorus</i>	Viscid rabbitbrush
cisp	<i>Cirsium species</i>	Unknown thistle
clif	<i>Cliff areas</i>	
clli	<i>Clematis ligusticifolia</i>	White virgins-bower
cost	<i>Corallorhiza striata</i>	Early coralroot
crab	<i>Cryptantha abata</i>	Low cryptanth
crsp	<i>Cryptantha species</i>	Unknown cryptanth
deca	<i>Deschampsia caespitosa</i>	Tufted hairgrass
ectr	<i>Echinocereus triglochidiatus</i>	Claretcup
elci	<i>Elymus cinereus</i>	Great basin wildrye
elcl	<i>Elymus elymoides</i>	Squirreltail
elsa	<i>Elymus salinus</i>	Salina wildrye/bullgrass
elsm	<i>Elymus smithii</i>	Western wheatgrass
eltr	<i>Elymus trachycaulus</i>	Slender wheatgrass
epvi	<i>Ephedra viridis</i>	Mormon/Brigham tea
eqar	<i>Equisetum arvense</i>	Meadow horsetail
erco	<i>Eriogonum corymbosum</i>	Corymb buckwheat
erra	<i>Eriogonum racemosum</i>	Redroot buckwheat
ersp	<i>Eriogonum species</i>	Unknown buckwheat
fapa	<i>Fallugia paradoxa</i>	Apache plume
feov	<i>Festuca ovina</i>	Sheep fescue
feru	<i>Festuca rubra</i>	Red fescue
geri	<i>Geranium richardsonii</i>	Richardson geranium
grsp	<i>Grass species</i>	Unknown grass
gusa	<i>Gutierrezia sarothrae</i>	Broom snakeweed
haac	<i>Haplopappus acaulis</i>	Stemless golden-weed
hebo	<i>Hedysarum boreale</i>	Northern sweetvetch
hodu	<i>Holodiscus dumosus</i>	Mountain spray
hyfi	<i>Hymenopappus filifolius</i>	Hyalineherb
CODE	SCIENTIFIC NAME	COMMON NAME

irmi	<i>Iris missouriensis</i>	Missouri iris
juba	<i>Juncus balticus</i>	Baltic rush
juco	<i>Juniperus communis</i>	Common juniper
juos	<i>Juniperus osteosperma</i>	Utah juniper
jusc	<i>Juniperus scopulorum</i>	Rocky Mountain juniper
koma	<i>Koeleria macrantha</i>	Junegrass
lale	<i>Lathyrus lanswertii</i>	Lanswert's sweetpea
lipe	<i>Linum perenne</i>	Blue flax
litt	<i>Litter</i>	
luar	<i>Lupinus argenteus</i>	Silvery lupine
mafr	<i>Mahonia fremontii</i>	Fremont mahonia
man	<i>Human dominance</i>	
mare	<i>Mahonia repens</i>	Oregon grape
mumo	<i>Muhlenbergia montana</i>	Mountain muhly
oefl	<i>Oenothera flava</i>	Yellow evening-primrose
oppo	<i>Opuntia polyacantha</i>	Central pricklypear
pamy	<i>Pachystima myrsinites</i>	Mountain-lover
pepr	<i>Penstemon procerus</i>	Small-flower penstemon
peut	<i>Penstemon utahensis</i>	Utah penstemon
phho	<i>Phlox hoodii</i>	Carpet phlox
phne	<i>Physaria newberryi</i>	Newberry's twinpod
pied	<i>Pinus edulis</i>	Pinyon/Two-needle pinyon
pifl	<i>Pinus flexilis</i>	Limber pine
pilo	<i>Pinus longaeva</i>	Bristlecone pine
pipo	<i>Pinus ponderosa</i>	Ponderosa pine
pipu	<i>Picea pungens</i>	Blue spruce
poan	<i>Potentilla anserina</i>	Common silverweed
poan	<i>Populus angustifolia</i>	Narrowleaf cottonwood
pofe	<i>Poa fendleriana</i>	Muttongrass
pogl	<i>Poa glauca</i>	Greenland bluegrass
pose	<i>Poa secunda</i>	Sandberg bluegrass
posp	<i>Poa species</i>	Unknown poa
potr	<i>Populus tremuloides</i>	Aspen
psme	<i>Pseudotsuga menziesii</i>	Douglas fir
putr	<i>Purshia tridentata</i>	Bitterbrush
quga	<i>Quercus gambelii</i>	Gambel oak
rhtr	<i>Rhus aromatica var trilobata</i>	Skunkbush
rice	<i>Ribes cereum</i>	Wax or squaw currant
rowo	<i>Rosa woodsii</i>	Woods rose
saex	<i>Salix exigua</i>	Narrowleaf willow
sasc	<i>Salix scouleriana</i>	Scouler's willow
save	<i>Sarcobatus vermiculatus</i>	Greasewood
scam	<i>Scirpus americanus</i>	Olney threesquare
sewe	<i>Senecio werneriiifolius</i>	Montane groundsel
shro	<i>Shepherdia rotundifolia</i>	Roundleaf buffaloberry
smst	<i>Smilacina stellata</i>	False Solomon's seal
spco	<i>Sphaeralcea coccinea</i>	Common globemallow
stco	<i>Stipa comata</i>	Needle-and-thread grass
sthy	<i>Stipa hymenoides</i>	Indian ricegrass
syor	<i>Symphoricarpos oreophilus</i>	Mountain snowberry
teca	<i>Tetradymia canescens</i>	Gray horsebrush
tegl	<i>Tetradymia glabrata</i>	Little-leaf horsebrush
trre	<i>Trifolium repens</i>	White clover
tyla	<i>Typha latifolia</i>	Broad-leaved cattail
wate	<i>Water</i>	

LOOKUP TABLE KEY AND CONTENTS

Each of the following lookup tables can be accessed by running 'veg95rel.aml' in the /home/arcddata/brca/flora directory. This aml relates these lookup tables to the 'veg95' cover and allows the reselection of polygons with the desired attribute values.

An example: we need to know the areas that have more than 20% total canopy cover from trees.

in the /home/arcddata/brca/flora

Arc: &run veg95rel followed by two carriage returns.

Arc: reselect veg95 can20 poly (the syntax for this is <reselect> <in_cover> <out_cover> {in_feature_class})

When prompted for the logical expression, you would type the desired application, the last three (3) letters of the desired lookup table, two backslashes (/), and the logical expression. (i.e., res can//tcan > 20) This will select all the polygons in 'veg95' with a total canopy of greater than 20%. Multiple logical expressions can be used in this method by using the same format with boulian operators for additional functions. (i.e., >,<=,or,ge,ne,etc.) (eg. res can//tcan > 20 or res gra//brin > 5)

VEG95.CAN

CODE	SCIENTIFIC NAME	COMMON NAME
abco	<i>Abies concolor</i>	White fir
acgl	<i>Acer glabrum</i>	Rocky Mountain maple
beoc	<i>Betula occidentalis</i>	Water birch
cele	<i>Cercocarpus ledifolius</i>	Curl-leaf mountain mahogany
cemo	<i>Cercocarpus montanus</i>	Alder-leaf mountain mahogany
juos	<i>Juniperus osteosperma</i>	Utah juniper
jusc	<i>Juniperus scopulorum</i>	Rocky Mountain juniper
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pilo	<i>Pinus longaeva</i>	Bristlecone pine
pipo	<i>Pinus ponderosa</i>	Ponderosa pine
pipu	<i>Picea pungens</i>	Blue spruce
poan	<i>Populus angustifolia</i>	Narrowleaf cottonwood
potr	<i>Populus tremuloides</i>	Aspen
psme	<i>Pseudotsuga menziesii</i>	Douglas fir
quga	<i>Quercus gambelii</i>	Gambel oak
tcan	total canopy cover	
hcan	high canopy cover	
mcan	medium canopy cover	combines abco, acgl, pifl, pilo, pipo, pipu, poan, potr, and psme
lcan	low canopy cover	combines beoc, juos, jusc, pied, and quga
		combines cele and cemo

VEG95.LIT

CODE	SCIENTIFIC NAME	COMMON NAME
bare	<i>Bare ground</i>	
clif	<i>Cliff areas</i>	
litt	<i>Litter</i>	
man	<i>Human dominance</i>	
wate	<i>Water</i>	

VEG95.FOR

CODE	SCIENTIFIC NAME	COMMON NAME
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acla	<i>Achillea lanulosa</i>
anpa	<i>Antennaria parvifolia</i>
anro	<i>Antennaria rosulata</i>
asco	<i>Astragalus convallarius</i>
aske	<i>Astragalus kentrophyta</i>
assp	<i>Astragalus species</i>
basa	<i>Balsamorhiza sagittata</i>
cach	<i>Castilleja chromosa</i>
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irmi	<i>Iris missouriensis</i>
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lipe	<i>Linum perenne</i>
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trre	<i>Trifolium repens</i>

Yarrow
Common pussytoes
Breaks pussytoes
Lesser rushy milkvetch
Kentrophyta
Unknown astragalus
Arrowleaf balsamroot
Common paintbrush
Narrowleaf paintbrush
Unknown thistle
White virgins-bower
Early coralroot
Low cryptanth
Unknown cryptanth
Claretcup
Meadow horsetail
Corymb buckwheat
Redroot buckwheat
Unknown buckwheat
Apache plume
Richardson geranium
Stemless golden-weed
Northern sweetvetch
Mountain spray
Hyalineherb
Missouri iris
Lanswert's sweetpea
Blue flax
Silvery lupine
Oregon grape
Yellow evening-primrose
Central pricklypear
Mountain-lover
Small-flower penstemon
Utah penstemon
Carpet phlox
Newberry's twinpod
Montane groundsel
False Solomon's seal
Common globemallow
Gray horsebrush
Little-leaf horsebrush
White clover

VEG95.GRA

CODE	SCIENTIFIC NAME
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COMMON NAME

agcr	<i>Agropyron cristatum</i>
brin	<i>Bromus inermis</i>
caat	<i>Carex athrostachrya</i>
caca	<i>Carex canescens</i>
deca	<i>Deschampsia caespitosa</i>
elci	<i>Elymus cinereus</i>
elel	<i>Elymus elymoides</i>
elsa	<i>Elymus salinus</i>
elsm	<i>Elymus smithii</i>
eltr	<i>Elymus trachycaulus</i>
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koma	<i>Koeleria macrantha</i>
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tyla	<i>Typha latifolia</i>

Crested wheatgrass
Smooth or Hungarian brome
Slender-beaked sedge
Pale sedge
Tufted hairgrass
Great basin wildrye
Squirreltail
Salina wildrye/bullgrass
Western wheatgrass
Slender wheatgrass
Sheep fescue
Red fescue
Unknown grass
Baltic rush
Junegrass
Mountain muhly
Muttongrass
Greenland bluegrass
Sandberg bluegrass
Unknown poa
Olney threesquare
Needle-and-thread grass
Indian ricegrass
Broad-leaved cattail

VEG95.SHR

CODE	SCIENTIFIC NAME
amut	<i>Amelanchier utahensis</i>
arfr	<i>Artemisia frigida</i>
arno	<i>Artemisia nova</i>
arpa	<i>Arctostaphylos patula</i>
artr	<i>Artemisia tridentata</i>
atca	<i>Atriplex canescens</i>
atco	<i>Atriplex confertifolia</i>
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mafr	<i>Mahonia fremontii</i>
poan	<i>Potentilla anserina</i>
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rhtr	<i>Rhus aromatica var trilobata</i>
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sasc	<i>Salix scouleriana</i>
save	<i>Sarcobatus vermiculatus</i>
shro	<i>Shepherdia rotundifolia</i>
syor	<i>Symphoricarpos oreophilus</i>

COMMON NAME
Utah serviceberry
Fringed sagebrush
Black sagebrush
Greenleaf manzanita
Big sagebrush
Four-wing saltbush
Shadscale
Martin's ceanothus
Rubber rabbitbrush
Viscid rabbitbrush
Mormon/Brigham tea
Broom snakeweed
Common juniper
Fremont mahonia
Common silverweed
Bitterbrush
Skunkbush
Wax or squaw currant
Woods rose
Narrowleaf willow
Scouler's willow
Greasewood
Roundleaf buffaloberry
Mountain snowberry

BRIEF ANALYSIS OF THE DISTRIBUTION OF MAJOR PLANT SPECIES AT BRYCE CANYON NATIONAL PARK

OVERVIEW

In an effort to gain a more detailed knowledge of existing vegetative resources, Park personnel have recently implemented a three part program to obtain greater in-depth information. Previous studies of plant life have been conducted on a generalized basis for years. These, however, appear to have been void of plant community analysis and the role played by dominant, co-dominant, and important subspecies. Beginning in the summer of 1993, field work was intensified to (1) identify plant communities and develop a park vegetative map using air photos and by on-site quantitative studies; (2) collect plant specimens to update park flora; and (3) locate rare plant species and their habitats.

From this work the most numerous to the most rare of species are noted. Several hundred plant species inhabit the park. Of these about 40 are considered as being prominent in given areas and 6 species are considered as rare. Most of these are discussed to some extent in this work.

METHODS

To gather the information obtained, several methods were used. Beginning in June of 1993 most of the summer months were spent collecting and preparing park specimens. As the month of May 1993 was missed, May of 1994 was spent collecting early blooming plants, mainly legumes, so an entire season could be represented. For this collecting period, more than 300 voucher specimens were collected, prepared and submitted to the Brigham Young University Herbarium in Provo, Utah for final identification and mounting. These collected specimens provide a variety of information, including (1) complexity of park flora; (2) where a given species may found; (3) representative rare species; and (4) new or unusual plant changes in park flora.

In June of 1994 mapping of plant communities was begun. A community is defined as an area which contains one to several species which provide the majority of plants for that area. Using recent air photographs in conjunction with topographic maps, outlines of plant communities were made. In many cases double checks were made to ascertain community content and extent. First, on-site visits to community types were made to ascertain the number and extent of species providing the canopy, the dominant understory species, and to determine the amount of bare ground. Walking through randomly selected areas for 100 meters using a six foot wide path was the method used. Next, when landforms allowed, a promontory or vantage point was used to overlook the same area. This to reinforce information and to help delineate the community on the photo and map.

To delineate dominant species on a map a minimum mapping unit of about 100 square meters was established. Information presented is represented by some 40 species prominent enough to be dominant, co-dominant, or an important subspecies in a given community. As community content varies in areas of the park, information is presented by species as they relate to communities. Information is also given by vegetative type, trees, shrubs, etc.

VEGETATIVE TYPES

CONIFEROUS TREES

PONDEROSA PINE

Ponderosa pine (*Pinus ponderosa*) is the most extensive species in the park. From the prairie-like north end of the park, at about 7600 feet where it is mixed with either black sage (*Artemisia nova*), bitter brush (*Purshia tridentata*), or various grasses it extends south on the plateau to the end of the park. Stands of ponderosa pine vary in content, dominance and vigor depending on soil, aspect and elevation. At elevations up to 8000 feet on relatively flat to northerly surfaces, mixed with a few Rocky Mountain juniper (*Juniperus scopulorum*), it provides a canopy for bitterbrush and/or western wheat grass (*Elymus smithii*). When the aspect is more southerly, when sunlight penetrates the canopy, or when associated with thinner soils, the understory is commonly greenleaf manzanita (*Arctostaphylos patula*).

In the elevation range between 8000-8400 feet when the aspect is northerly with less sunlight and lower evaporation, ponderosa pine becomes co-dominant with Douglas fir (*Pseudotsuga menziesii*) and usually has an understory of bitter brush and/or snowberry (*Symphoricarpos oreophilus*) and sometimes Martin's lilac (*Ceanothus martinii*).

Above 8400 feet ponderosa pine is mixed with white fir (*Abies concolor*) and Douglas fir. In areas of level to northerly aspect it is a subspecies to fir. With a southerly aspect, i.e., on the slopes north of Podunk Creek, it is again dominant due to sun penetration of the canopy and higher evaporation. Where soils are dryer, thinner and sun penetration is higher, manzanita is the common understory. Sometimes manzanita is co-dominant or even more abundant than ponderosa pine. To the east of the plateau, throughout the eroded breaks areas, ponderosa pine stands vary with aspect, soil depth, and elevation. In the red, thin soil knolls between 7000-8000 feet ponderosa pine, sometimes is mixed with pinyon pine (*Pinus edulis*). These ponderosa pine tend to be stunted, slow growing, and distorted, yet still cling to life. In and along washes where soils are deeper and water more plentiful it is mixed with Rocky Mountain juniper. Here they are healthier and more plentiful.

In the south eastern part of the park, ponderosa pine dominate the riparian areas, but relinquish north facing slopes to Gambel's oak (*Quercus gambelii*) and south facing slopes to pinyon pine. Understories here are composed primarily of serviceberry (*Amelanchier utahensis*), alder-leaf mountain-mahogany (*Cercocarpus montanus*), and Gambel's oak.

Reproduction and regeneration of ponderosa pine varies. On the plateau area on elevations up to about 8400 feet a reasonable number of seedlings were noted. Above 8400 feet in the white fir zone there are very few seedlings. On the red slopes in the east of the park are very few seedlings, and a few are scattered in the eastern wash areas.

Many ponderosa pine are infected with mistletoe (*Arceuthobium vaginatum*). Most of these are on the west side of the plateau area from about 8000-8400 feet along the park boundary.

PINYON PINE

Pinyon pine is probably second to ponderosa pine in its park distribution. It extends the north-south length of the park from 7600 to 9000 feet. On the plateau it is found on open knolls and along the breaks where soils are thin and sunlight penetrates. To the east of the breaks on eroded knolls and extended spurs, it is dominant where the aspect is southerly. There it is usually mixed with Utah juniper (*Juniperus osteosperma*), sometimes ponderosa pine and has alder-leaf mountain-mahogany as an understory. Pinyon pine is very slow growing and long lived, however, seedlings are scarce.

DOUGLAS FIR

Douglas fir ranks third among conifers in the park. Douglas fir is usually found above 7800 feet on north facing slopes,

in draws where moisture is preserved, in some riparian areas, and in relatively flat areas above 8400 feet. Its distribution is broken due to habitat nature. Under 8400 feet it is commonly in company with ponderosa pine. Douglas fir is often found in draws with aspen (*Populus tremuloides*) and sometimes Rocky Mountain juniper. On the southeastern slopes in well established drainage areas, i.e., Swamp Canyon, it is mixed with ponderosa pine and riparian species such as serviceberry and alder-leaf mountain-mahogany.

At about 8400 feet on the plateau, conifer communities become a complex of Douglas fir, white fir, and ponderosa pine. Moving southerly with increasing elevation, dominance shifts to white fir with Douglas fir second and then ponderosa pine. Even at higher elevations ponderosa pine is dominant on slopes or breaks where sunlight penetrates canopy.

Douglas fir is in trouble with both parasites and competition with white fir. Probably 50-60% of this species is infected with witches broom (*Arceuthobium douglasii*). Plants from sapling stage to maturity are warped, bent, and generally deformed. As a result few if any seed are produced on a great number of trees reducing replacement possibilities. Meanwhile healthy white fir seedlings are outcompeting Douglas fir on a ten to one ratio.

WHITE FIR

White fir is the major species on the plateau above 8400 feet. At 8400 feet there exists a complex of white fir, Douglas fir, ponderosa pine, a few Rocky Mountain juniper, and where soils are a bit more calcified, limber pine (*Pinus flexilis*). The understory, where the canopy is restricted, consists of snowberry, mountain lilac, and Oregon grape (*Mahonia repens*). On the edge of these conifer stands where soils are thin are stands of golden current (*Ribes aureum*). On the breaks and attending slopes where sun penetrates and soils are thin, manzanita dominates.

With increased elevation to the south, white fir attains dominance, with Douglas fir second, and then ponderosa pine. Some areas have attained a closed canopy with very little understory. Those areas with an understory usually consist of Oregon grape and common juniper (*Juniperus communis*).

There is also a considerable accumulation of litter and deadfall especially in the closed canopy areas, i.e., Shaker Springs. Above 8500 feet white fir reproduction has a ten to one ratio over other conifers.

JUNIPER

There are three species of juniper in the park, all having been mentioned previously, but will be given individual consideration now.

Rocky Mountain juniper is found mainly on the plateau as a co-species with ponderosa pine and/or Douglas fir. It inhabits cooler, damper areas than does Utah juniper, therefore it is found at higher elevations. As individuals and in sparse stands, it extends the length of the plateau. Off the plateau to the east in draws and drainage areas it is found with ponderosa pine and also with riparian species down to about 7000 feet. It may also be mixed with Utah juniper up to about 7500 feet.

Utah juniper inhabits the drier more open areas in the easterly portions of the park. Most extensively it is mixed with pinyon pine on south facing and open slopes with alder-leaf mountain-mahogany as an understory. As Utah juniper does well in highly calcified soils, it is often found as almost pure stands where this soil exists.

Common juniper is a low growing prostrate plant found mainly above 8000 feet under a heavy canopy of fir or pine and also in draws under aspen where soils are damp.

BLUE SPRUCE

Blue spruce (*Picea pungens*), one of the most beautiful of all conifers, is restricted in habitat to heavy soil in damp or

even boggy areas. In the park the main distribution is adjacent to the Podunk Creek meadow area. Mixed with ponderosa pine and aspen, this community extends from Yovimpa Pass south of the meadow, west to the park boundary. Several other small stands are found in draws near the south end of the plateau area. Blue spruce reproduction is healthy.

LIMBER PINE

Limber pine is a very wide spread species on the plateau from 7600 to 9000 feet, but never in dominance. Limber pine may be found in association with ponderosa pine, Douglas fir, and white fir in a complex or with any one of them in stands. It seems to do well in highly calcified soils and is almost always found on open knoll areas with bristlecone pine (*Pinus longaeva*). Limber pine reproduction appears to be good.

BRISTLECONE PINE

Bristlecone pine is one of the most unique of plant species. On the plateau from 7600 to 9000 feet where there is a white outcrop, it is found almost the length of the park. In a few areas, as marked on the photos, there are small dominant stands. In most cases it is mixed with limber pine and/or pinyon pine. Reproduction seems good as observed by cones and seedlings.

DECIDUOUS TREES

GAMBEL'S OAK

Gambel's oak is by far the most extensive leafy tree in the park. Its distribution is to the east off the plateau from 6500 to 8000 feet. In the north areas of the park it is mainly restricted to portions of draws. Moving south into eroded areas it is found in riparian areas with serviceberry, alder-leaf mountain-mahogany, and bitter brush. In some draws with deeper soil accumulations it is mixed with Rocky Mountain juniper and big sage (*Artemisia tridentata*). Gambel's oak is most common on southeastern and southern spurs in the park. The heaviest stands are in draws and on north facing slopes where more water is retained. Rocky Mountain juniper and ponderosa pine are sometimes scattered through stands with alder-leaf mountain-mahogany and big sage as an understory. In some alluvial areas where grazing once occurred, i.e., Noon and Sheep Creek canyons, pure stands of rubber rabbitbrush (*Chrysothamnus nauseosus*) are interspersed with oak. Oak stands are well established and healthy.

ASPEN

Aspen as previously mentioned is scattered in the park. Aspen is a transition species found in coves or shady areas where a bit more moisture exists. There are several small stands on the plateau. One adjacent to Podunk Creek meadow as mentioned and others are on the west side in Puma and Oak Hollows adjacent to the park boundary. These are mixed with white and Douglas fir and have common juniper as understory. On the east side of the park scattered stands exist in the upper eroded areas, i.e., Swamp Canyon, where they co-habitate with Douglas fir.

COTTONWOOD

Narrowleaf cottonwood (*Populus angustifolia*) and Fremont cottonwood (*Populus fremontii*) are both riparian species. Narrowleaf occurs at higher elevations to about 7600 feet, as in Bryce Canyon, Swamp Canyon, and Mutton Hollow. Sub-canopy species include Rocky Mountain juniper, Gambel's oak, willow (*Salix spp.*), Red-osier dogwood (*Cornus sericea*) and big sagebrush. At about 7200 feet the two cottonwoods may be found together depending on aspect and water. At lower elevations Fremont cottonwood is found in conjunction with Rocky Mountain juniper, willow, and big sagebrush.

WILLOWS

Several species of willow are found in the park with narrow-leaf (*Salix exigua*) being the most common. It is found

from the seeps adjacent to Highway 12 in the north to riparian areas south on Lower Podunk Creek. Other willow species of note are Bebb willow (*Salix bebbiana*), Drummond willow (*Salix drummondiana*), and Geyer willow (*Salix geyeriana*). As willows are indicators of water on or near the surface, they are found with other water lovers such as dogwood and Woods' rose (*Rosa woodsii*).

ROCKY MOUNTAIN MAPLE

Rocky Mountain maple (*Acer glabrum*) is usually at home in Utah mountains between 6000 to 7000 feet in areas with somewhat damp, humus rich soil. In the park, however, a few stands exist in the drainages east of Yovimpa Pass at about 7800 feet, on the shady slopes north of Bristlecone point at about 8500 feet and several other scattered stands in similar habitats. Due to the rather harsh circumstances under which it exists in the park its physical features are abnormal, i.e., small stems, seeds, and very small leaves.

SHRUBS

Manzanita

Manzanita is the most extensive shrub in the park. Its range extends, in part, to most areas of the park from 7000 to 9000 feet. As a low growing shrub, it is an understory species to trees and in their absence, provides ground cover. Manzanita occupies a variety of habitats, but is most competitive where sunlight is ample and soils are relatively thin. It does not do well however on white outcrops of highly calcareous soils. Its most dominating communities are east facing slopes on reddish soils, usually with varying stands of ponderosa pine. Plants throughout the park appear healthy.

BITTERBRUSH

Bitterbrush is probably second to manzanita in abundance. It too extends to most areas of the park from 6500 to 8500 feet. Unlike manzanita, bitterbrush does best in rather mature soil with less sunlight. The most competitive stands are on slightly north facing slopes often in combination with western wheat grass as an understory in open stands of ponderosa pine up to an elevation of about 8200 feet as seen in the north end of the park. In higher elevations in more closed canopy cover it becomes scattered. Off the plateau in eroded areas bitterbrush is patchy and as a riparian species is mixed with serviceberry, alder-leaf mountain-mahogany, and other species but none create a dominance. Along some of the washes, i.e., Campbell Creek, it is found in association with cliff-rose (*Purshia mexicana*).

SAGEBRUSH

Several species of sagebrush are found in the park, but only two are abundant enough to type a community.

Black sagebrush (*Artemisia nova*) is most abundant on the plateau from 7600 to 8500 feet. It is most prevalent on the northern end of the park. Here plant life transitions to the south from prairie type where black sagebrush is mixed with grasses and herbs, to mixture of ponderosa pine, bitterbrush, and sagebrush. In the upper Shinglemill area, adjacent to the park headquarters and in the meadow area south of the Bryce Point intersection, black sagebrush is in cohabitation with grasses and shrubs such as horsebrush (*Tetradymia glabrata*) and viscid rabbitbrush (*Chrysothamnus viscidiflorus*) which set these communities apart.

Big sagebrush is primarily found off the plateau in washes where alluvium has been deposited forming deeper soils. Big sagebrush on occasions grows to 6 feet tall with root systems that attain at least the same depth. It is found interspersed with Gambel's oak on lower slopes and in some areas receives heavy competition from rubber rabbitbrush.

Fringed sagebrush (*Artemisia frigida*), a very attractive plant in the late summer and early fall, is found scattered on sandy alluvial areas on the east side of the park at about 7500 feet mixed with alder-leaf mountain-mahogany and Gambel's oak. This species is found in small isolated pockets and never dominates a vegetative community.

MOUNTAIN-MAHOGANY

Two species of mountain-mahogany are found in the park. In some places they cohabit, but are generally separated.

Curl-leaf mountain-mahogany (*Cercocarpus ledifolius*) is at home mainly on the eastern rim of the plateau. It thrives there almost the entire length of the park from 7600 to 9000 feet.

Found with it at various locations are pinyon pine and sometimes alder-leaf mountain-mahogany.

Alder-leaf mountain-mahogany is more at home below the breaks. It frequents the eroded spurs with pinyon pine, in the draws with riparian species and on north facing slopes as an understory for Gambel's oak. It is the most wide spread shrub in the eastern area of the park.

RABBITBRUSH

Like sagebrush, several species of rabbitbrush inhabit the park but only two are abundant.

Viscid rabbitbrush is an endinginous species in the plateau grass-shrub communities. It is a major component in the open areas, especially on thin soils.

Rubber rabbitbrush is generally classified as an invader or increaser. It prefers the same general habitat as does big sagebrush. When stands are dominant it is indicative of disturbance as in overuse by livestock.

POTENTILLA

There are five species of potentilla in the park all of which are found in riparian areas or areas in which water is close to the surface. A common identifier of these plants are the bright yellow rose-like flowers. Two of these are common enough for mention. Common silverweed (*Potentilla anserina*) is a low growing, vine-like plant. A good example of this can be found in the meadow south of the visitor's center. Shrubby cinquefoil (*Potentilla fruticosa*) is an upright, shrubby species growing up to three feet tall. This species may be found in the Podunk Creek meadow and many of the drainages in the east side of the park.

FREMONT'S MAHONIA

Fremont's mahonia (*Mahonia fremontii*) is barely in its natural range at the edge of drainage areas as they leave the eastern side of the park. It is normally found on alluvial areas and on clay-loam knolls between 6500-7500 feet. In the park stands are located adjacent to Mossy Cave Parking lot just in the park up Bryce Canyon, in lower Swamp Canyon, and in Noon Canyon.

SILVER BUFFALOBERRY

Silver buffaloberry (*Shepherdia argentea*), named because of it's narrow light colored leaves, is a common riparian species in eastern Utah. It is at home in sandy alluvial areas. Only a few areas in the park provide this habitat. Some examples are in Bryce Canyon just inside the park, in the lower reaches of Swamp Canyon, and in Lower Podunk Creek.

MOUNTAIN SPRAY

Mountain spray (*Holodiscus dumosus*) fills an important niche on the breaks. It is one of a very few plants which grow on the steep slopes off the breaks. It never forms dense stands, but from the middle of the park south a number of these

plants cling tenaciously to the upper 50 to 60 feet of the cliffs.

HORSEBRUSH

Horsebrush is another plant that grows on steep breaks. It too is sparsely located on the same locations as mountain spray, but is found further north in the park. Horsebrush is also found in the black sagebrush communities on the northern end of the park.

WOODS' ROSE

Woods' rose prefers the same habitat as do willows. Woods' rose is found in seep areas, adjacent to springs, and in riparian areas with high water tables and unrestricted sunlight. From Highway 12 to the Lower Podunk Creek, there are clumps of Woods' rose in these habitat types.

SKUNKBUSH

Skunkbush (*Rhus aromatica* var. *trilobata*) is a prominent riparian shrub at middle elevations between 6500 to 7500 feet. When in bloom its odor is rather offensive, but its red fruit is rather attractive in the fall. In the lower drainages on the eastern side of the park it is found in scattered clumps from the Mossy Cave parking lot to Lower Podunk Creek.

FORBS

PRIMROSE

Of all the flowers in the park the primroses (*Oenothera* spp.) are the most extensive on the plateau and may be the most noticeable. There are several species. Each retain similar characteristics, with the blossoms ranging from almost pure white to deep orange. All are low growing and are found in most soil types. They do not form integral parts of a community, but may be found in any communities in the park.

GOLDENWEED

Thrifty goldenweed (*Haplopappus armerioides*) is a small clumping herb with thin narrow leaves and bright golden yellow flowers. This plant thrives on rocky, thin reddish colored soils. In the area just north of the Highway 12 drop into Bryce Canyon are found a few knolls of approximately one acre each which are dominated by this forb. It is also found in similar areas throughout the park, but not to the same extent as the above mentioned locations.

OREGON GRAPE

Oregon grape is a small, low growing forb with holly-like leaves and small bright yellow flowers which mature into grape-like purple seeds in late fall. It seldom exceeds a height of six to eight inches. In all closed canopy wooded areas on the plateau Oregon grape forms a common understory, however it never develops a dominance. It is indicative of developing soils with more moisture retention. Good locations for observation are southwest of Natural Bridge on the south facing slopes dominated by spruce-fir with closed canopies.

BALSAMROOT

An interesting situation that occurs south of the picnic area near Farview is a long narrow meadow adjacent to the road covered with approximately 35% Balsamroot (*Balsamorhiza sagittata*). This species is identified by its bright yellow flower and large mule-ear shaped leaves which retain their shape into late fall. This species is indicative of rocky,

shallow soil. At this location it is also mixed with curl-leaf mountain-mahogany and golden current.

PENSTEMON

Several species of Penstemon are found in the park. This species is here mentioned because of its beautiful flowering nature. Two forms are found on the plateau. The first form is an upright plant with multiple flowers growing from single stems. Good examples of this type are Eaton's penstemon (*Penstemon eatonii*) with red flowers and Dusty penstemon (*Penstemon comarrhenus*) with purple flowers. The second is a mat-like plant forming a small ground cover. This species is called Mat penstemon (*Penstemon caespitosus*) with pale purple flowers and is easily confused with Kentrophyta (*Astragalus kentrophyta*). With several species in the park the flowers range in color, but all have the characteristic bugle shaped petal. These plants may be found in all open to semi-open areas.

CARPET PHLOX

In some unusual circumstances small herbs sometimes dominate. At the north end of the park just east of the stock drive area are two rather rocky calcified knolls of about an acre each. These are about 60% covered with a blanket of Carpet phlox (*Phlox hoodii*).

DEATH CAMAS

Elegant death camas (*Zygadenus elegans*) is a bog dwelling species of semi-closed canopy and is here mentioned because of its location near water sources. This is a typical lily species with long slender leaves and it blooms in early spring. The individual plants grow up to eighteen inches tall and have pale yellow-white flowers. The most common location is adjacent to the Yovimpa Spring and forms a cover of about 2 acres.

GRASSES AND SEDGES

GRASSES

There are several grass dominated areas in the park. Some in the north are prairie-like, others similar to the Shinglemill Swale are wet-dry. All contain various percentages of grass species and some are intermixed with sedges. Due to early drought, 1994 was a bad year for grass and sedge identification. In a year where more grasses mature other species will undoubtedly be found.

The prairie-like communities at the north end of the park are interspersed with grasses and black sagebrush. Sheep fescue (*Festuca ovina*), needle-and-thread grass (*Stipa comata*), and Sandberg's bluegrass (*Poa secunda*) were identified from this area and dominate the grasses of the area.

In the upper Shinglemill Swale tufted hairgrass (*Deschampsia caespitosa*), western wheatgrass, junegrass (*Koeleria macrantha*), and mountain muhly (*Muhlenbergia montana*) were identified.

Podunk Creek meadow is another grassy area. The only grass to mature enough for identification was smooth brome (*Bromus inermis*) and is located adjacent to Forest Service land that had been previously seeded.

Probably the most extensive grass in the forested area between 7800 and 8200 feet is western wheat grass. On north slopes from the Bryce Point intersection north to the Fairyland area grasses make an extensive understory for ponderosa pine second only to bitterbrush.

INDIAN RICEGRASS

Indian ricegrass (*Stipa hymenoides*) is one of the most extensive grasses in the park. It prefers rather open areas of well drained sandy soil and will mature even in harsh conditions. Where these soil types exist it is found to some extent in the park. A good example is in the area of the mixing circle road.

WILDRYE

Wildrye (*Elymus spp.*) is notable because of its large clump forming nature, tall strong reed-like stems, and distinctive seed bearing heads. Wildrye is a good indicator of shallow groundwater and good soil formation. Good clumps are found on the west side of the park road south of the Bryce Point turnoff and in the East Creek drainage.

RARE SPECIES

During the 1994 summer extensive research for 20 rare species previously found in proximity to the park was conducted. In the Brigham Young University Herbarium nearly 100 specimens were examined for identification and habitat location. Data was recorded on those locations that existed between the Sevier River on the west and Henrieville on the east, then from Widstoe Junction on the north to Alton on the south. A number of these sites were located and plants observed giving knowledge as to what to find in the park.

Of the 315 specimens collected from the park during 1993 and 1994 264 have been identified and recorded. Of these 39 were not on existing park plant lists. None of the 39 are rare, but some are unusual. Ward's milkvetch (*Astragalus wardii*), for instance, has not been previously collected in Garfield County.

A number of new sites were located for known park species. Platy penstemon (*Penstemon bracteatus*) was located on the upper slopes of Gravel Canyon and east of Rainbow Point both at about 8500 feet on red formations. Yellowish cryptanth (*Cryptantha ochroleuca*) was found in upper Horse Hollow at 8100 feet and Bristlecone Point at 9100 feet. A number of locations were found of Reveal's paintbrush (*Castilleja parvula* var. *revealii*) all on white outcrops. Several of these are about 8000 feet on the north side of the road between the Bryce Point intersection and Bryce Point. The largest of the Reveal's paintbrush locations is just outside the park in Dave's Hollow on Forest Service land. No new sites were found of Paria breadroot (*Pediomelum pariense*) or Maguire's campion (*Silene petersonii* var. *minor*).

It was suspected that Arizona willow (*Salix arizonica*), a Category II species, might be in the park. Two sites were located within a few miles of the park, but none in the park proper.

EXOTIC SPECIES

Exotic or invader species move into areas for various reasons. Some introduced species will readily outcompete native species for habitat. Palatability for wildlife and/or livestock of species plays a factor in the reduction of native species to the advantage of invader species. Alteration of habitat by man or natural factors may also allow the introduction of new species. Many exotic species have been introduced by man for various reasons as well as seed dispersal by wildlife and even wind. There are a variety of exotic species in the park such as thistle (*Cirsium spp.*) found in a multitude of habitats and Fremont's goosefoot (*Chenopodium fremontii*) located in the sewage treatment ponds. Only two species are prominent enough to be mentioned and also attempted to be controlled.

TAMARIX

Tamarix (*Tamarix chinensis*) is a high water table obligate and will aggressively outcompete native species for water. It is one of the most salt tolerant species found and will even exude salts from stems during transpiration. It has the ability to adapt its root system to find water, even in the most harsh of conditions. Depending on the depth of the water table tamarix will develop a vertical or lateral root system. Once established tamarix is difficult to remove because it will sprout from stumps and it is a prolific seed producer which are easily carried by wind and wildlife.

RUSSIAN OLIVE

Russian olive (*Eleagnus angustifolia*) is an exotic species that was introduced by man because of its ability to provide wind breaks, wildlife cover in disturbed areas, and also for its ability to provide some food for domestic and wild animals. It is primarily found in areas with high water tables and can even outcompete Tamarix for dominance in these

areas.

SUMMARY

A brief consideration has been given in this paper to the most prominent species in the park. Their existence in most cases is determined by aspect, soil, elevation, and in some cases competition, i.e., big rabbitbrush. Utilization of these factors is of assistance in determining what to expect in the various park areas.

Some unhealthy situations exist especially with witch's broom invasion of Douglas fir. This should be given some attention. The mistletoe problem in ponderosa pine is less critical.

The closed canopy of white fir, Douglas fir, and ponderosa pine are potential hazards due to the amount of down/dead woody material and also litter. Re-establishment of standard fire regimes would help avert a natural catastrophe in the park.

Rare species do not appear to be in immediate danger from visitors. Most are in areas which are inaccessible or away from used sites. This of course applies as long as visitor access is controlled.

This study, though more in-depth than previous ones, could be enhanced by quantitative work from each particular area of the park.

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